

Appendix A

A. Rehabilitation of Mechanical Systems At Wells, Pump Stations And Pipelines

A.1 General

An evaluation study has been conducted of the existing transmission facilities, to determine the requirements and costs for rehabilitation or replacement of mechanical items at wells, pump stations and pipelines. Field visits were carried out with assistance from staff of NGWA (Northern Governorates Water Authority) to assess the condition of the existing works, and to establish the rehabilitation requirements. A separate evaluation study has been conducted on the rehabilitation requirements for the electrical, instrumentation and control facilities.

The information presented in this report is based on the following:

- Observations made during field trips to the various sites; and
- Available data and records for the pump stations, wells and pipelines collected from the NGWA ROUs (Regional Operational Units).

From evaluation of this information, remedial measures have been identified that would improve the reliability and performance of the wells, pump stations and transmission lines.

A.2 Wells

Data on the wells that have been assessed is presented in **Table A-1**. In general, the types of problems observed at the wells can be categorized as follows:

1. Concrete base slab at ground surface: For most of the wells, the concrete base suffers from cracks, irregularities, and a rough uneven surface. For some wells there is no concrete base.
2. Well pump mounting: most of the borehole pumps are mounted on steel clamps and the borehole is not closed or sealed, thus allowing any foreign solids or fluids to flow into the well. These conditions pose the risk of contamination of the well water, and the risk of damage to the pump.
3. Well pump discharge pipe-work and accessories: The layout of discharge piping and flow meters at most of the wells is poorly arranged, with incompatible sizes of pipes and fittings, and not installed to any recognized standard.
4. Valves: Air valves, pressure gauges, and check valves have not been installed at many of the wells.
5. Flow meters: These have not been installed at many of the wells.
6. Boundary fence and gate: At most wells, these are in bad condition, broken or missing.
7. Control buildings: At most wells, the control buildings are in a miserable condition. Only a few of the control buildings are in a good and acceptable condition.

The conditions found at the wells are presented in **Table A-1**, the cost estimates for rehabilitating well-heads are presented in **Table A-2**, and photographs at selected wells are shown in **Figures A-1 to A-7**.

Table A-1 STATUS OF WELLS

Well ID	WELL NAME	Discharge (m ³ /h)*	Head (m)	Power (kW)	Fence & Gate	Control Building	Well Pump Concrete Base	Piping Arrangement	Air Valve	Isolating Valve	Check Valve	Flow Meter	Pressure Gauge
F 1310	Aqeb Well K114	84	300	132	Without	Sheet metal barracks	Deteriorated	Untidy	Without	With	With	With	Without
F 1312	Aqeb Well K112	87	300-348	140	Without	Sheet metal barracks	Deteriorated	Untidy	With	With	Without	With	Without
F 1079	Aqeb Well K111(B)	84	300	132	With	Cement block building without windows and doors	No base	Untidy	With	With	With	With	Without
F 3930	Aqeb Well K111(A)	84	300	132	With	Cement block building without windows and doors	No base	Untidy	With	With	With	With	Without
F 1333	Aqeb Well K110	96	300	129	With	Good building	Deteriorated	Untidy	Without	With	Without	With	Without
F 1389	Aqeb Well K109	114	300	185	Without	Cement block building with corrugated steel sheet roof and without door	Deteriorated	Untidy	Without	With	With	With	Without
AL2689	Aqeb Well K107	45	350-400	92	Fence with broken gate	Cement block building with corrugated steel sheet roof	No base	Untidy	Without	With	With	With	Without
AL3517	Aqeb Well K106 (B)	70	300	100	Fence in bad condition, no gate	Sheet metal barracks without door	Deteriorated	Untidy	Without	With	With	With	Without
AL1274	Aqeb Well K106 (A)	60	250	100	Fence in bad condition, no gate	Sheet metal barracks without door	No base	Untidy	Without	With	Without	With	Without
AL1225	Aqeb Well K104	120	290-300	110	Fence without gate	Cement block building with corrugated steel sheet roof	Broken concrete base	Untidy	Without	With	With	With	Without
AL3518	Aqeb Well K103 (2)	96	300	132	Fence in bad condition	Good building	No base	Untidy	Without	With	With	With	Without
AL1495	Aqeb Well K103 (1)	90	300	132	Fence in bad condition	Good building	No base	Untidy	Without	Without	Without	With	Without
AL1273	Aqeb Well K102.5	132	300	132	Fence in bad condition with gate	Sheet metal barracks	Cracked concrete base	Untidy	Without	With	With	With	Without
AL3422	Zamlah Well	48	250	75	Fence in bad condition, no gate	Cement block building without windows	No base	Untidy	With	With	With	With	Without
AL1265	Aqeb Well K102	150	300	170	Fence without gate	Sheet metal barracks without door	Deteriorated	Untidy	Without	With	With	With	Without
AL3513	Aqeb Well K101(A)	80	200	75	Without	Sheet metal barracks without door and windows	No base	Untidy	Without	With	With	With	Without
AL3681	Aqeb Well K101(B)	100	250	162	Without	Sheet metal barracks without door and windows	Deteriorated	Untidy	Without	With	With	With	Without
AL1193	Aqeb Well K 96(2)	140	300	173	With	Cement block building with corrugated steel sheet roof	Broken concrete base	Untidy	Without	With	With	With	Without
AL3362	Aqeb Well K 96(1)	45	250	66	With	Cement block building with corrugated steel sheet roof	Broken concrete base	Untidy	With	With	Without	With	Without
AL1241	Aqeb Well K095	96	300	132	With	Sheet metal barracks without door and windows	No base	Untidy	Without	With	With	With	Without
AL3004	Aqeb Well K094.5	132	300	174	Fence with broken gate	Cement block building with corrugated steel sheet roof	Deteriorated	Untidy	With	With	With	With	Without
AL1486	Aqeb Well K094	90	250	100	Fence in bad condition, no gate	Cement block building with corrugated steel sheet roof	No base	Untidy	Without	With	With	With	Without
AL3423	Aqeb Well K093.5	78	250	75	Without	Good building	Deteriorated	Untidy	Without	With	With	With	Without
AL1485	Aqeb Well K093	87	200	132	With	Broken windows	No base	Untidy	Without	With	With	With	Without
AL3452	Aqeb Well K091.5	102	248	95.5	Incomplete fence	Broken windows	Cracked	Untidy	Without	With	With	With	Without

Table A-1 STATUS OF WELLS

Well ID	WELL NAME	Discharge (m ³ /h)*	Head (m)	Power (kW)	Fence & Gate	Control Building	Well Pump Concrete Base	Piping Arrangement	Air Valve	Isolating Valve	Check Valve	Flow Meter	Pressure Gauge
AL1558	Aqeb Well K090	50	200	92	Fence in bad condition, no gate	Cracked cement block building with broken windows and corrugated steel sheet roof	No base	Untidy	Without	With	With	With	Without
AL1491	Rawdah Ameera Basma Well	92	200	92	With	Only block walls	Deteriorated	Untidy	With	With	With	With	Without
AL1490	Um Al Jemal Well 3	60	200-250	60	Without	Cement block building with corrugated steel sheet roof and broken windows	Deteriorated	Untidy	Without	With	Without	With	Without
AL2710	Zatary Well 3	45	250	75	With	Cement block building without windows	Deteriorated	Untidy	With	With	With	With	Without
AL3002	Zatary Well 4	42	250	92	With	Good building	No base	Untidy	With	With	With	With	Without
AL3003	Zatary Well 5	38	251	66	With	Good building	No base	Untidy	Without	With	With	With	Without
AL3463	Zatary Well 6	45	200-250	66	Without	Good building	No base	Untidy	Without	With	With	With	Without
AL3375	Zatary Well 7	42	250	66	Without	Good building	No base	Untidy	Without	With	With	With	Without
AL3376	Zatary Well 9	30	297	92	Without	Good building	No base	Untidy	Without	With	With	With	Without
AL3377	Zatary Well 10	33	350-400	92	Without	Good building but door in bad condition	No base	Untidy	Without	With	With	With	Without
AG3004	Tabaqat Fahel PS and Well 3	Without Pump			With	Good building	Good						
AB3157	Tabaqat Fahel PS and Well 8	160	50		With	Good building	Good	Untidy	Without	With	With	With	Without
AG3005	Tabaqat Fahel PS and Well 6	160-170	20-22		With	Good building	Deteriorated	Untidy	Without	With	With	With	Without
AG3000	Tabaqat Fahel PS and Well 1	192			With	Good building	Good	Untidy	Without	With	With	With	Without
AB0542	Tabaqat Fahel PS and Well 9	72+108	120-22	30	Without	Good building	Bad inlet	Untidy	Without	With	With	With	Without
AE1010	Wadi Al Arab Well 4	300	126-150	250	With	Good building with corrugated steel sheet roof	Good	Untidy	Without	Without	Without	With	Without
AE1009	Wadi Al Arab Well 3	400	100	300	Needs maintenance	Good building but needs interior maintenance	Good	Untidy	Without	Without	With	With	Without
AE1008	Wadi Al Arab Well 2	320			With	Very good building	Good	Untidy	With	With	Without	Without	Without
AE1007	Wadi Al Arab Well 1	180	126-150	250	With	Very good building	Good	Untidy	Without	Without	Without	With	Without
AE1011	Wadi El Arab Well 5	240	125-150	200	With	Very good building	No base	Untidy	Without	With	With	With	Without
AE1012	Wadi El Arab Well 7	80		90	With	Very good building	Good	Untidy	Without	With	Without	With	Without
AB1355	Manshyeh Pump Station 2	90	Artesian										
AB3003	Manshyeh Pump Station 1		155	75									
AB1375	Juhfiyya PS Well 1		100	68									
AB1441	Juhfiyya PS Well 1A		150										
AL3563	Um Al Jemal Well 1	50	250	66	Incomplete fence in bad condition without gate	Good building	Deteriorated	Untidy	Without	With	With	With	Without
AE1004	Al-Elbait University	25											
AL1023	Khaldyeh PS Well 17	65	200	45									

Table A-2 COST ESTIMATE FOR REHABILITATION OF WELLS

Well ID	Well Name	New Well Head Concrete Base, JD	Well Head Base Flange, JD	Well Head Flange, Discharge Elbow & dismantling flange, JD	Air & Vacuum Valve & Pressure Gauge, JD	Check Valve, JD	Isolating Valve, JD	Flow Meter, JD	Flow Meter Fittings, JD	Discharge Pipes & Support, JD	Fence & Gate, JD	New Control Building, JD	Control Building Repair, JD	Contingencies 20%	Estimated Cost, JD
F 1310	Aqeb Well K114	100	500	700	700	600	0	0	0	300	2500	2500	0	1580	9480
F 1312	Aqeb Well K112	100	500	700	700	600	0	0	0	300	2500	2500	0	1580	9480
F 1079	Aqeb Well K111(B)	100	500	700	700	0	0	0	0	300	2500	2500	0	1460	8760
F 3930	Aqeb Well K111(A)	100	500	700	700	0	0	0	0	300	0	2500	0	960	5760
F 1333	Aqeb Well K110	100	500	700	700	600	0	0	0	300	0	0	1000	780	4680
F 1389	Aqeb Well K109	100	500	700	700	0	0	0	0	300	2500	2500	0	1460	8760
AL2689	Aqeb Well K107	100	500	700	700	0	0	0	0	300	2500	2500	0	1460	8760
AL3517	Aqeb Well K106(B)	100	500	700	700	0	0	300	300	0	2500	0	1000	1220	7320
AL1274	Aqeb Well K106(A)	100	500	700	700	0	0	0	300	300	0	0	0	520	3120
AL1225	Aqeb Well K104	100	500	700	700	600	0	0	300	300	2500	2500	0	1640	9840
AL3518	Aqeb Well K103 (2)	100	500	700	700	600	0	0	300	300	2500	0	1000	1340	8040
AL1495	Aqeb Well K103 (1)	100	500	700	700	600	0	0	300	300	0	2500	0	1140	6840
AL1273	Aqeb Well K102.5	100	500	700	700	0	0	0	300	300	2500	2500	0	1520	9120
AL3422	Zamlah Well	100	500	700	700	0	0	0	300	300	2500	2500	0	1520	9120
AL1265	Aqeb Well K102	100	500	700	700	600	0	0	300	300	2500	2500	0	1640	9840
AL3513	Aqeb Well K101 (A)	100	500	700	700	600	0	0	300	300	2500	2500	0	1640	9840
AL3681	Aqeb Well K101 (B)	100	500	700	700	600	0	0	300	300	0	0	0	640	3840
AL1193	Aqeb Well K96 (2)	100	500	700	700	600	500	0	300	300	2500	2500	0	1740	10440
AL3362	Aqeb Well K96 (1)	100	500	700	700	600	500	0	300	300	0	0	0	740	4440
AL1241	Aqeb Well K095	100	500	700	700	0	0	0	300	300	0	2500	0	1020	6120
AL3004	Aqeb Well K094.5	100	500	700	700	600	0	0	300	300	2500	2500	0	1640	9840
AL1486	Aqeb Well K094	100	500	700	700	0	0	0	300	300	2500	2500	0	1520	9120
AL3423	Aqeb Well K093.5	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320
AL1485	Aqeb Well K093	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320
AL3452	Aqeb Well K091.5	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320
AL1558	Aqeb Well K090	100	500	700	700	0	0	0	300	300	2500	2500	0	1520	9120
AL1491	Rawdah Ameera Basma Well	100	500	700	700	0	0	0	300	300	2500	2500	0	1520	9120
AL1490	Um Al Jemal Well 3	100	500	700	700	0	0	0	300	300	2500	2500	0	1520	9120
AL2710	Zatary Well 3	100	500	700	700	600	0	0	300	300	2500	2500	0	1640	9840
AL3002	Zatary Well 4	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320
AL3003	Zatary Well 5	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320
AL3463	Zatary Well 6	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320
AL3375	Zatary Well 7	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320

Table A-2 COST ESTIMATE FOR REHABILITATION OF WELLS

Well ID	Well Name	New Well Head Concrete Base, JD	Well Head Base Flange, JD	Well Head Flange, Discharge Elbow & dismantling flange, JD	Air & Vacuum Valve & Pressure Gauge, JD	Check Valve, JD	Isolating Valve, JD	Flow Meter, JD	Flow Meter Fittings, JD	Discharge Pipes & Support, JD	Fence & Gate, JD	New Control Building, JD	Control Building Repair, JD	Contingencies 20%	Estimated Cost, JD
AL3376	Zatary Well 9	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320
AL3377	Zatary Well 10	100	500	700	700	0	0	0	300	300	2500	0	1000	1220	7320
AG3004	Tabaqat Fahel PS&Well 3	0	0	0	700	0	0	0	0	0	0	0	1000	340	2040
AB3157	Tabaqat Fahel PS&Well 8	0	0	0	700	0	0	0	0	300	0	0	1000	400	2400
AG3005	Tabaqat Fahel PS&Well 6	0	0	0	700	0	0	0	0	300	0	0	1000	400	2400
AG3000	Tabaqat Fahel PS&Well 1	0	0	700	700	0	0	0	0	0	0	0	1000	480	2880
Ab0542	Tabaqat Fahel PS&Well 9	100	500	700	700	0	0	0	0	300	0	0	1000	660	3960
AE1010	Wadi Al Arab Well 4	0	0	0	700	0	0	0	0	0	0	0	0	140	840
AE1009	Wadi Al Arab Well 3	100	0	0	700	0	0	0	0	0	0	0	0	160	960
AE1008	Wadi Al Arab Well 2	0	0	0	0	0	0	0	300	0	0	0	0	60	360
AE1007	Wadi Al Arab Well 1	0	0	0	0	0	0	0	300	0	0	0	0	60	360
AE1011	Wadi Al Arab Well 5	0	0	0	700	0	0	0	0	0	2500	0	1000	840	5040
AE1012	Wadi Al Arab Well 7	0	0	0	700	0	0	0	0	0	2500	0	1000	840	5040
AB1355	Manshyeh PS 2	100	500	700	700	600	0	0	0	300	0	0	0	580	3480
AB3003	Manshyeh PS 1	100	500	700	700	600	0	0	0	300	0	0	0	580	3480
AB1375	Juhfiyya PS Well 1	100	500	700	700	600	0	0	0	300	0	0	0	580	3480
AB1441	Juhfiyya PS Well 1A	100	500	700	700	600	0	0	300	300	2500	0	1000	1340	8040
AL3563	Um Al Jemal Well 1	100	500	700	700	600	0	0	300	300	2500	0	1000	1340	8040
AE1004	Al-Elbait University	100	500	700	700	600	0	0	300	300	2500	0	1000	1340	8040
AL1023	Khaldyeh PS Well 17	100	500	700	700	600	0	0	300	300	2500	0	1000	1340	8040
Total Estimated Cost, JD															344,520



Figure A-1: Aqeb Wells, K90



Figure A-2: Aqeb Wells, K90



Figure A-3: Um El Jemal Well 3



Figure A-4: Zatory Wells 7 and 9



Figure A-5: Zatory Well 9



Figure A-6: Wadi Al Arab Well 5



Figure A-7: Wadi Al Arab Well 5

A.3 Pump Stations

Twelve pump stations have been evaluated, for which the available pump data are shown in **Table A-3**. Conditions at three of the pump stations are shown in photographs in **Figures A-8 to A-10**.

The estimated costs for mechanical rehabilitation of the pump stations are summarized in **Table A-4**.

The specific conditions found at each pump station are described below.

A.3.1 Wadi Al-Arab PS0

The pump station contains 3 pump units with a total capacity of 1975 m³/hr. PS0 receives water from the Tabaqat Fahel well-field and delivers it to PS1, at the site of the Wadi Al Arab water treatment plant. The pump station was placed into service in 1999, although it has not yet been accepted from the contractor; as a result, the pump station not typical of the remaining pump stations described subsequently.

The condition of the pump sets is as follows:

- Only one pump unit is running; the other two are out of service.
- Pumps are in good condition, but routine preventive maintenance is required.
- The drive motors on two pumps are defective due to high running temperatures in the bearings.
- A coupling guard has been removed and is missing.
- Pipe work and valves are in good condition except for the control valves, which are defective and not reliable for continuous operation.
- Pressure gauges are not operating.
- Pump and motor foundations are dirty.
- The floor around the pumps is dirty.
- The identification name plates on pumps and motors are covered with paint and dirt.
- The pump house building is in good condition.

Table A-3 PUMP DATA

Pump Station	Pump No.	Q (m3/h)	H (m)	Motor (KW)	Pump Manufacturer	Motor Speed (RPM)
Wadi Arab PS0	1	625	320	672	Ingersoll Rand	2970
	2	625	320	672	Ingersoll Rand	2970
	3	625	320	672	Ingersoll Rand	2970
Wadi Arab PS1, New Station	1	576	235	560	Ingersoll Rand	2970
	2	576	235	560	Ingersoll Rand	2970
	3	576	235	560	Ingersoll Rand	2970
Wadi Arab PS1, Old Station	1	567	220	500	Ingersoll Rand	2970
	2	567	220	500	Ingersoll Rand	2970
	3	567	220	500	Ingersoll Rand	2970
	4	567	220	500	Ingersoll Rand	2970
Wadi Arab PS2, New Station	1	666	250	675	Ingersoll Rand	2970
	2	666	250	675	Ingersoll Rand	2970
	3	666	250	675	Ingersoll Rand	2970
Wadi Arab PS2, Old Station	1	567	216	500	Ingersoll Rand	
	2	567	216	500	Ingersoll Rand	
	3	567	216	500	Ingersoll Rand	
	4	567	216	500	Ingersoll Rand	
Wadi Arab PS3, New Station	1	666	250	675	Ingersoll Rand	2970
	2	666	250	675	Ingersoll Rand	2970
	3	666	250	675	Ingersoll Rand	2970
Wadi Arab PS3, Old Station	1	567	220	500	Ingersoll Rand	
	2	567	220	500	Ingersoll Rand	
	3	567	220	500	Ingersoll Rand	
	4	567	220	500	Ingersoll Rand	
Zubdat	1	300	250	320	Schneider	1490
	2	500	200	420	Schneider	1485
	3	500	200	400	Schneider	1485
	4	300	250	320	Schneider	1490
	5	300	190	290	Weir	1470
Hofa	1	380	265	440	Schneider	1477
	2	300	250	320	Schneider	1490
	3	200	250	225	Ritz	1490
Samad	1	100	200	115	Ritz	2970
	2	150	250	175	Ritz	2970
	3	300	250	420	Ritz	2980
	4	200	250	230	Jet	2980
Huson	1	100	350	200	Rotus	1485
	2	50	450	110	Halbarga	2980
	3	250	100	132	Standard	1480
Um El Lulu	1	300	220	250	Standard	
	2	380	265	440	Schneider	
	3	300	250	320	Schneider	
	4	300	350	500	Weir	
Bwaydah	1	50	250	55	RKP	
	2	60	250	90	Standard	
	3	75	200	110	Rotus	
	4	100	200	110	Turbosan	
Khaldyeh	1	150	300	250	Standard	
	2	200	250	210	Rotus	
	3	200	250	200	Ritz	
	4	50	300	75	Standard	
	5	200	100	110	Standard	
Zatary	1	500	250	500	Schneider	
	2	500	250	500	Halbarga	
	3	380	265	440	Schneider	
	4	380	265	440	Schneider	
	5	500	250	540	Schneider	
	6	500	100	250	Turbosan	
	7	500	117	250	Autoria	
	8	128	100	250	KSB	
	9	500	100	250	Rotus	
	10	500	100	250	Rotus	
	11	128	100	250	KSB	



Figure A-8: Huson Pump Station



Figure A-9: Samad Pump Station



Figure A-10: Bwaydah Pump Station

Table A-4 Cost Estimate for Mechanical Rehabilitation of Pump Stations

Pump Station	Pump No.	Q (m3/h)	H (m)	Motor (KW)	Physical Condition and/or Rehabilitation Requirements								Estimated Cost (JD)
					Pumping Unit	Concrete Foundation	Suction & Delivery Pipe	Suction & Delivery Isolating Valves	Flow Control & Non Return Valves	Vent valve and pressure gauge	Pump House	Fence & Gate	
PS0	P1	625	320	672	Motor bearings modification	Cleaning	Routine Preventive Maintenance	Routine Preventive Maintenance	Repairs	New Pressure Gauge	Good Condition	Good Condition	40,000
	P2	625	320	672									
	P3	625	320	672									
PS1 New	P1	576	220	560	Cleaning and Preventive Maintenance	Cleaning	Routine Preventive Maintenance	Routine Preventive Maintenance	Maintenance	New Vent & Pressure Gauge	Good Condition		20,000
	P2	576	220	560									
	P3	576	220	560									
PS1 Old	P1	567	235	500	Maintenance	Cleaning & Touching Repair	Maintenance	Maintenance	Maintenance	New Vent & Pressure Gauge	Good Condition Preventive Maintenance	Good Condition	100,000
	P2	567	235	500									
	P3	567	235	500									
	P4	567	235	500									
PS2 New	P1	666	250	675	Cleaning and Preventive Maintenance	Cleaning	Routine Preventive Maintenance	Routine Preventive Maintenance	Routine Preventive Maintenance	New Vent & Pressure Gauge	Good Condition		20,000
	P2	666	250	675									
	P3	666	250	675									
PS2 Old	P1	567	216	500	Maintenance	Cleaning & Touching Repair	Maintenance	Maintenance	Maintenance	New Vent & Pressure Gauge	Good Condition Preventive Maintenance	Good Condition	100,000
	P2	567	216	500									
	P3	567	216	500									
	P4	567	216	500									
PS3 New	P1	666	250	675	Cleaning and Preventive Maintenance	Cleaning	Routine Preventive Maintenance	Routine Preventive Maintenance	Routine Preventive Maintenance	New Vent & Pressure Gauge	Good Condition		20,000
	P2	666	250	675									
	P3	666	250	675									
PS3 Old	P1	567	220	500	Maintenance	Cleaning & Touching Repair	Maintenance	Maintenance	Maintenance	New Vent & Pressure Gauge	Good Condition Preventive Maintenance		100,000
	P2	567	220	500									
	P3	567	220	500									
	P4	567	220	500									
Zubdat	P1	300	250	320	Major Maintenance	New Foundation	New Pipe Work	New Valves	New Valves	New Vent & Pressure Gauge	New Pump House	Maintenance	90,000
	P2	500	200	420									
	P3	500	200	400									
	P4	300	250	320									
	P5	300	190	290									
Hofa	P1	380	265	440	Major Maintenance	New Foundation	New Pipe Work Arrangement	New Valves	New Valves	New Vent & Pressure Gauge	Maintenance	Maintenance	60,000
	P2	300	250	250									
	P3	200	250	250									
Samad	P1	100	200	200	New Pumps	New Foundation	New Pipe Work	New Valves	New Valves	New Vent & Pressure Gauge	New Building	Maintenance	100,000
	P2	150	250	250									
	P3	300	250	250									
	P4	200	250	250									

Table A-4 Cost Estimate for Mechanical Rehabilitation of Pump Stations

Pump Station	Pump No.	Q (m3/h)	H (m)	Motor (KW)	Physical Condition and/or Rehabilitation Requirements								Estimated Cost (JD)
					Pumping Unit	Concrete Foundation	Suction & Delivery Pipe	Suction & Delivery Isolating Valves	Flow Control & Non Return Valves	Vent valve and pressure gauge	Pump House	Fence & Gate	
Huson	P1	100	350	200	New Pumps	New Foundation	New Pipe Work Arrangement	New Valves	New Valves	New Vent & Pressure Gauge	New Building	New Fence and Gauges	85,000
	P2	50	450	110									
	P3	250	100	132									
Um El Lulu	P1	300	220	250	Maintenance	New Foundation	New Pipe Work	New Valves	New Valves	New Vent & Pressure Gauge	New Building	Maintenance	75,000
	P2	380	265	440									
	P3	300	250	320									
	P4	300	350	500									
Bwaydah	P1	60	250	90	New Pumps	New Foundation	New Pipe Work	New Valves	New Valves	New Vent & Pressure Gauge	New Building	Maintenance	85,000
	P2	75	200	110									
	P3	100	200	110									
Khaldyeh	P1	150	300	250	Maintenance	New Foundation	New Pipe Work	New Valves	New Valves	New Vent & Pressure Gauge	Maintenance	Maintenance	75,000
	P2	200	250	210									
	P3	200	250	200									
	P4	50	300	75									
	P5	200	100	110									
Zatary	P1	500	250	500	Maintenance	Repair	Maintenance	Maintenance	New Valves	New Vent & Pressure Gauge	Maintenance	Maintenance	100,000
	P2	500	250	500									
	P3	380	265	440									
	P4	380	265	440									
	P5	500	250	540									
	P6	500	100	250									
	P7	500	117	250									
	P8	128	100	250									
	P9	500	100	250									
	P10	500	100	250									
	P11	128	100	250									
Total Cost, JD													1,070,000

A.3.2 Wadi Al-Arab PS1

PS1 delivers water to PS2; PS2 delivers water to PS3; and PS3 delivers water to Zubdat Reservoir in Irbid. Each of these pump stations contains two pump houses, designated as “old” and “new”, which were placed into operation in 1983 and 1999 respectively.

For the old pump units installed in 1983:

- Four units are each rated at 567 m³/hr at 220 m head.
- All Units are operable after 20 years of use and running satisfactorily.
- Pump casings are rusty due to excessive leakage of water from the pump gland.
- Motors are operable and in acceptable condition.
- Pump glands are rusty with excessive water leakage.
- Pump bearings are rusty.
- Control valves are operating but in very dirty condition.
- Isolating valves on both suction and delivery sides are operable but dirty and rusty.
- All pressure gauges are either not operating or missing.
- Coupling guards are missing.
- Pump-gland drain pipes are rusty and blocked.
- Pump and motor foundations are dirty.
- The floor around the pumps is dirty and covered with a layer of contaminated water.
- The pump house building is in good condition.

For the new pump units installed in 1999:

- Three units are each rated at 576 m³/hr at 235 m head.
- All pumps are operating.
- Pump glands are leaking water excessively.
- Pump-gland drain piping is blocked and rusty.
- Pump flow control valves cannot maintain an open position due to a defective pilot control system.
- Pressure gauges are not working.
- Isolating valves on both the suction and delivery of pumps are in good condition.
- The pump and motor foundations are dirty.
- The motor bearings are running hot.
- The floor around the pumps is dirty.
- Identification name plates on both pumps and motors are covered with dirt.

A.3.3 Wadi Al-Arab PS2

For the old pump units installed in 1983:

- Four units are each rated at 567 m³/hr at 220 m head.
- All Units are operable after 20 years of use and running satisfactorily.
- Pump casings are rusty due to excessive leakage of water from the glands.
- Pump bearings are dirty and rusty.
- Control valves are operating but in very dirty condition.
- Isolating valves on both suction and delivery sides are operable but dirty and rusty.
- All pressure gauges on suction and delivery lines are either missing or defective.
- Pump-gland drain pipes are rusty and blocked.
- Coupling guards are missing.
- Pump and motor foundations are dirty and covered with a layer of contaminated water.
- The pump house building is in good condition.

For the new pump units installed in 1999:

- Three units are each rated at 666 m³/hr at 250 m head.
- All units are operating.
- Pump glands are leaking water excessively.
- Pump-gland drain piping is blocked and rusty.
- Pump flow control valves cannot maintain an open position due to a defective pilot control system.
- Pressure gauges are not working.
- Isolating valves on both suction and delivery are in good condition.
- Coupling guards are missing.
- Pump and motor foundations are dirty.
- Motor bearings are running hot.
- The floor around the pumps is dirty.
- Identification name plates on both pumps and motor are covered with dirt.

A.3.4 Wadi Al-Arab PS3

For the old pump units installed in 1983:

- Four units are each rated at 567 m³/hr at 220 m head.
- All units are operable after 20 years of use and running satisfactorily.
- Pump casings are rusty due to excessive leakage of water from the glands.

- Pump bearings are dirty and rusty.
- Control valves are operable but in very dirty condition.
- Isolating valves on both suction and delivery are operable but dirty and rusty.
- All pressure gauges on suction and delivery lines are missing or defective.
- Pump-gland drain pipes are blocked and rusty.
- Coupling guards are missing.
- Pump and motor foundations are dirty.
- The floor around the pumps is dirty and covered with a layer of contaminated water.
- The pump house building is in good condition.

For the new pump units installed in 1999:

- Three units each rated at 666 m³/hr at 250 m head.
- All units are operable.
- Pump glands are leaking water excessively.
- Pump-gland drain piping is blocked and rusty.
- Pump flow control valves cannot maintain an open position due to defective pilot control system.
- Pressure gauges are not working.
- Isolating valves on both suction and delivery are in good condition.
- Pump and motor foundations are dirty.
- Motor bearings are running hot.
- The floor around the pumps is dirty.
- Coupling guards are missing.
- Identification name plates on both pumps and motor are covered with paint and dirt.

A.3.5 Hofa Pump Station

- Pumping capacity: 880 m³/h
- Current water demand: 480 m³/h
- Three pumping units as follows:
 1. P1 380 m³/h, 265 m Head, 440 kW
 2. P2 300 m³/h, 250 m Head, 320 kW
 3. P3 200 m³/h, 250 m Head, 225 kW

The general condition of the pumping units is as follows:

- Pumps are run manually.

- Flow control valves are missing.
- Flow control is done by throttling the isolating valve on the discharge side.
- Pumps & motors are rusty and dirty.
- Identification name plates for pumps and motors are unreadable, covered with paint and rust.
- Coupling guards are missing.
- Pump glands are rusty due to excessive water leakage.
- Gland drains are blocked.
- Pump bearings are rusty and dirty.
- Air valves and pressure gauges on both suction and delivery are missing.
- The floor near the pumps is covered with contaminated water.
- Pumping unit foundations need to be renewed.
- Suction and delivery pipes are poorly arranged and without pipe supports; needs to be rehabilitated.
- New suction and delivery valves and control valves are needed.
- The pump house needs maintenance to bring it up to an acceptable condition.

A.3.6 Zubdat Pump Station

- Pumping capacity: 1900 m³/h
- Current water demand: 800 m³/h
- Five pump units as follows:
 1. P1 500 m³/h, 200 m Head, 420 kW
 2. P2 300 m³/h, 200 m Head, 400 kW
 3. P3 200 m³/h, 190 m Head, 290 kW
 4. P4 300 m³/h, 250 m Head, 320 kW
 5. P5 300 m³/h, 250 m Head, 320 kW

The general condition of the pumps is as follows:

- Pumps are run manually.
- Flow control valves are missing.
- Flow control is done by throttling the isolating valve on the discharge side.
- Pumps and motors are rusty and dirty.
- Identification name plates for pumps and motors are unreadable, covered with paint and rust.
- Coupling guards are rusty.
- Gland drains are blocked.

- Pump bearings are rusty and dirty.
- valves and pressure gauges on both suction and delivery are missing.
- Pump glands are rusty and leaking water excessively.
- Pump bearings are rusty.
- Pump and gland drains are blocked.
- Air valves & pressure gauges on both suction and delivery are missing.
- The floor near the pumps is covered with contaminated water due to gland leakage and blocked drains.
- Pump foundations are in bad condition and need to be renewed.
- Suction and delivery lines are poorly arranged, rusty and without pipe supports. A new pipe-work arrangement with valves is needed.
- A new pump house is to be constructed.

A.3.7 Samad Pump Station

- Pump capacity: 750 m³/h
- Current water demand: 380 m³/h
- Of the four pump units, three are installed inside a small pump house and the fourth one is installed outdoors. The pump units are as follows:
 1. P1 100 m³/h, 200 m Head, 115 kW.
 2. P2 150 m³/h, 250 m Head, 175 kW.
 3. P3 300 m³/h, 250 m Head, 420 kW.
 4. P4 200 m³/h, 250 m Head, 230 kW.

The general condition of the pumping units is as follows:

- Pumps are run manually.
- Flow from each pump is controlled by throttling the isolating valve on the discharge side.
- Pumps are rusty and dirty.
- Identification name plates for pumps & motors are unreadable, covered with paint and dirt.
- Coupling guards are missing.
- Pump glands are rusty and water leakage is excessive.
- Pumping-gland drains are blocked.
- Pump bearings are rusty.
- Air valves and pressure gauges on both suction and delivery sides are missing.
- New pumping units, equipped with flow control valves and suitable for parallel operation, are recommended.

- Suction and delivery pipes for all pumps are poorly arranged, without pipe supports; a new pipe-work arrangement, with valves on common headers on the suction and delivery sides, is recommended.
- Pump foundations are in bad condition; new foundations are recommended.
- The pump house is small, without a door; the floor is in bad condition, covered with contaminated water around the pumps. A new building providing more interior space is recommended.

A.3.8 Al Huson Pump Station

- Pumping capacity: 400 m³/h
- Current water demand: 350 m³/h
- Three pump units, two installed inside the pump house and the third installed outdoors, are as follows:
 1. P1 100 m³/h, 350 m Head, 200 kW
 2. P2 50 m³/h, 450 m Head, 110 kW
 3. P3 250 m³/h, 100 m Head, 132 kW

The general condition of the pump units is as follows:

- Pumps are run manually.
- Flow control for each pump is done by throttling the isolating valve on the discharge side.
- Pumps and motors are rusty and dirty.
- Identification name plates for pumps & motors are unreadable, covered with paint and dirt.
- Coupling guards are missing.
- Pump glands are rusty and water leakage is excessive.
- Pump bearings are rusty.
- Pump-gland drains are blocked.
- Suction and delivery lines are poorly arranged, without pipe supports; a new pipe-work arrangement with valves and headers is needed.
- Air valves and pressure gauges on both suction and delivery lines are missing.
- Pump foundations are in very bad condition, for the two pumps inside the pump house.
- A new pump house building is recommended.

A.3.9 Um El Lulu Pump Station

- Pump capacity: 1280 m³/h
- Current water demand: 940 m³/h

- Four pump units are installed inside the pump house:
 1. P1 300 m³/h, 220 m Head, 250 kW
 2. P2 380 m³/h, 265 m Head, 440 kW
 3. P3 500 m³/h, 250 m Head, 320 kW
 4. P4 300 m³/h, 350 m Head, 500 kW

The general condition of the pump units is as follows:

- Pumps are run manually.
- Flow control valves are missing.
- Flow control for each pump is done by throttling the isolating valve on the discharge side.
- Pumps and motors are rusty and dirty.
- Identification name plates for pumps & motors are unreadable, covered with paint and dirt.
- Coupling guards are missing.
- Pumps glands are rusty and water leakage from glands is excessive.
- Pump bearings are rusty.
- Suction and delivery pipes are poor arranged, rusty and without pipe supports; a new pipe-work arrangement with valves and headers is needed.
- Air valves and pressure gauges on both suction and delivery lines are missing.
- Pump foundations are in very bad condition, new foundations are required.
- A new pump house building is recommended.
- The floor around the pumps is dirty, covered with a layer of contaminated water.
- The pump house is in poor condition; as a minimum it needs maintenance on the door and windows, repairs to the walls, and painting.

A.3.10 Bwaydah Pump Station

- Pump capacity: 235 m³/h
- Current water demand: 180 m³/h
- Three pump units, two installed inside in the pump house and one out side, are as follows:
 1. P1 60 m³/h, 250 m Head, 90 kW
 2. P2 75 m³/h, 200 m Head, 110 kW
 3. P3 100 m³/h, 200 m Head, 110 kW

The general condition of the pumping units is as follows:

- Pumps are operated manually.

- Flow control valves are missing.
- Flow control for each pump is done by throttling the discharge isolating valve.
- Pumps and motors are rusty and dirty.
- Identification name plates for pumps & motors are unreadable, covered with paint and dirt.
- Coupling guards are missing.
- Pump bearings are rusty.
- New pump units are recommended, equipped with control valves and suitable for parallel operation.
- Suction and delivery pipes for all pumps are poorly arranged, with incompatible pipe sizes, no pipe supports, corroded and leaking from joints; a new pipe-work arrangement is recommended, with common headers on both the suction and delivery sides.
- Isolating valves are in bad condition and need replacement.
- Check valves are in bad condition and need replacement.
- Air valves and pressure gauges on both suction and delivery are missing.
- Pump foundations are in bad condition; new foundations are needed.
- The pump house is small, without a door; floors are dirty and covered with contaminated water around the pumps; a new building with sufficient space for all the pumps is needed.

A.3.11 Khaldyeh Pump Station

- Pump capacity: 800 m³/h
- Current water demand: 650 m³/h
- Five pump units are installed inside the pump house:
 1. P1 150 m³/h, 300 m Head, 250 kW
 2. P2 200 m³/h, 250 m Head, 210 kW
 3. P3 200 m³/h, 200 m Head, 200 kW
 4. P4 50 m³/h, 300 m Head, 75 kW
 5. P5 200 m³/h, 100 m Head, 110 kW

The general condition of the pumping units is as follows:

- Pumps are run manually.
- Flow control valves are missing.
- Flow is controlled by throttling the discharge isolating valve on the pump discharge side.
- Pumps and motors are rusty and dirty.

- Identification name plates for pumps and motors are unreadable, covered with paint and dirt.
- Coupling guards are missing.
- Pump glands are rusty and leaking water excessively.
- Pump bearings are rusty.
- The pump-gland drain pipe is blocked.
- Suction and delivery pipes and valves are arranged poorly: heavily rusted, without pipe supports; replacement is recommended.
- Air valves and pressure gauges on both the suction and delivery sides are missing.
- Pump foundations are in bad condition; new foundations are needed.
- The pump house is in good condition but needs maintenance.

A.3.12 Zatory Pump Station

- Pump capacity: 4516 m³/h
- Current water demand: 3800 m³/h
- Eleven pump units are installed in two pump houses, with six units in one pump house and five in a second pump house:
 1. P1 500 m³/h, 250 m Head, 500 kW
 2. P2 500 m³/h, 250 m Head, 500 kW
 3. P3 380 m³/h, 265 m Head, 440 kW
 4. P4 380 m³/h, 265 m Head, 440 kW
 5. P5 500 m³/h, 250 m Head, 540 kW
 6. P6 500 m³/h, 100 m Head, 250 kW
 7. P7 500 m³/h, 117 m Head, 250 kW
 8. P8 128 m³/h, 100 m Head, 250 kW
 9. P9 500 m³/h, 100 m Head, 250 kW
 10. P10 500 m³/h, 100 m Head, 250 kW
 11. P11 128 m³/h, 100 m Head, 250 kW

The general condition of the pump units is as follows:

- Pumps are run manually.
- Flow control valves are missing.
- Flow is controlled by throttling the isolating valve on the discharge side.
- Some identification name plates for pumps & motors are unreadable, covered with paint and dirt.
- The pumps and motors are in good condition.
- Coupling guards are missing.

- Most of the air valves and pressure gauges are missing.
- Suction and delivery pipes and valves need maintenance.
- Pump foundations are in acceptable condition, but need touch-up repairs and painting.
- Both pump houses are in good condition, but minor repairs are required.

A.4 Transmission Pipelines

The condition of pipelines in the existing transmission system has been evaluated, to identify pipelines and valves that should be replaced or rehabilitated. The existing transmission system is divided into the east and west transmission systems, described separately below. The results of the pipeline evaluation are summarized in **Table A-5**, in terms of the status of pipelines and valves, and rehabilitation/replacement requirements.

A.4.1 East Transmission System

This transmission system contains three major pipelines, as shown on **Figure A-11**. From east to west, a major pipeline carries water from the Aqeb well field to the Zatory pump station; a second pipeline carries water from Zatory pump station to the Hofa reservoir in the Irbid distribution system. A third major pipeline carries water south from Zatory pump station to Khaldyeh. In addition, the east transmission system contains many small branch lines connecting groundwater wells to the transmission system. These pipelines are described below.

Aqeb – Zatory Pipeline

The length of this pipeline is 32km: 3 km of 200mm diameter pipe, followed by 11 m of 500mm and 18 km of 600mm. The pipe is ductile iron with push-on joints, pressure class k9, cement-lined internally and bitumen-coated externally. The pipe was installed about 20 years ago and is in acceptable condition, although leaks or bursts have occurred at three corroded pipe sockets in recent years.

An old deteriorated steel pipeline of 400mm diameter with welded steel joints runs in parallel to the transmission pipeline, built originally by IPC (Iraqi Petroleum Company). This pipeline has been taken out of service, except for a small segment that is used to deliver water from the Um Al Jemal wells.

Al Zatory - Hofa Pipeline

This line is 48 km long, consisting of a 600 mm diameter ductile-iron pipe, Class k9 with push-on joints, cement-lined internally and bitumen-coated externally. The pipeline was installed in 1977 and is in acceptable condition. However, it has been observed that when the pressure at Zatory pump station exceeds 200-210m or the flow exceeds 900 m³/h, water leakage occurs along the first 3 km near the pump station. Pressure surges from rapid valve closures downstream are the suspected cause of the leakage.

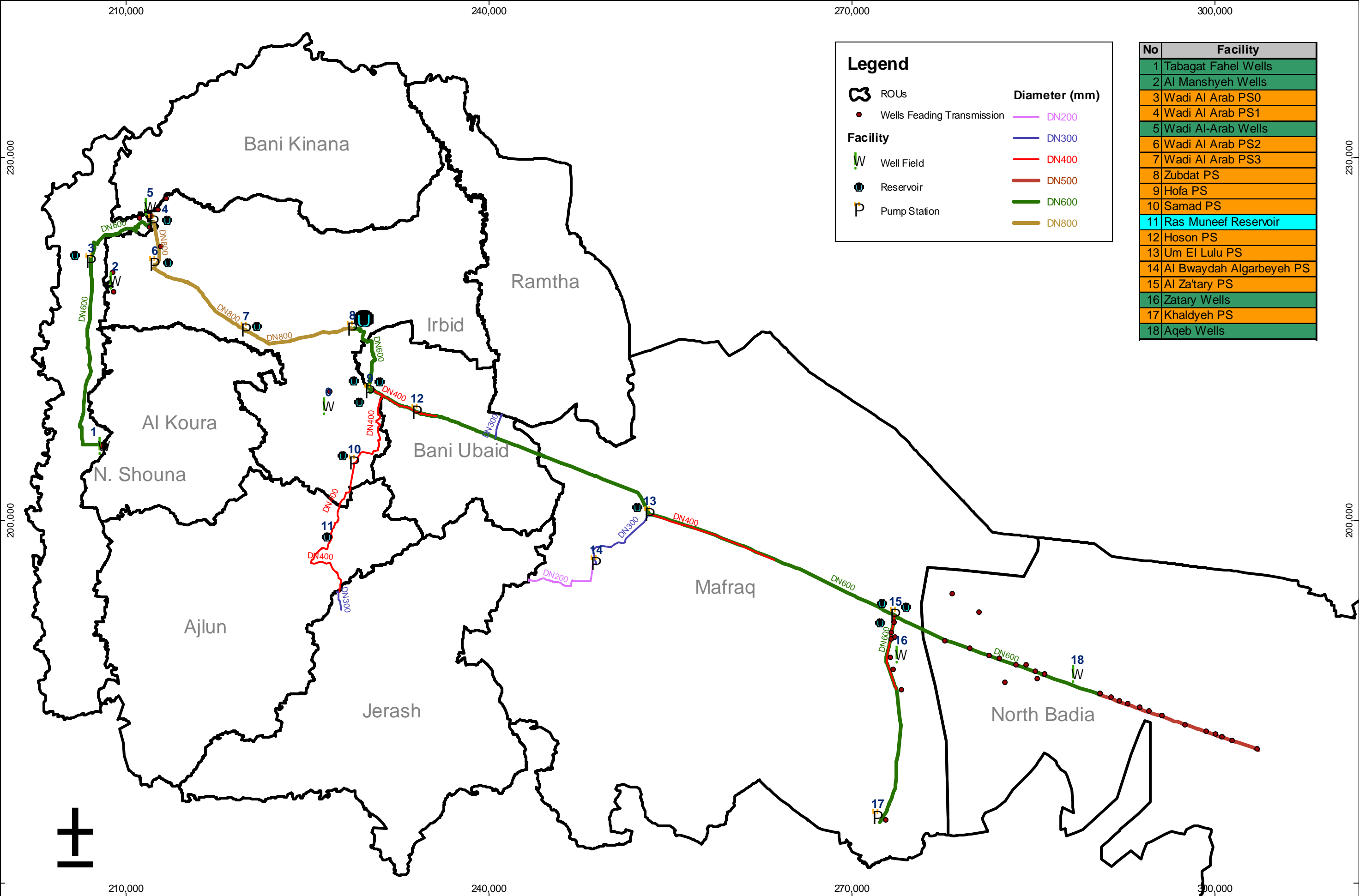
A 12 km portion of a parallel 400mm steel pipeline with welded joints remains in service, between the air base at Mafraq and the Um El Lulu pump station. Pipe breaks and leaks are frequent on this pipeline, especially in the above-ground portions. Its future use will be limited to local distribution rather than water transmission.

Zatory - Khaldiyeh Pipeline

The pipeline connecting these two pump stations is 17 km long, consisting of a 600 mm diameter ductile-iron pipe, Class k9 with push-on joints, cement-lined internally and bitumen-coated externally. The pipeline is old, but is providing good service without trouble. Essentially all of the air valves and wash-out valves along the pipeline need maintenance.

Table A-5 Transmission Pipelines: Rehabilitation Needs

Location	Pipeline	Status of Pipeline	Valves
East Transmission System	Aqeb - Zatory line, 32 km length	Acceptable condition; repairs needed	New Valves
	Zatory - Hofa line, 48 km length	Acceptable condition; limit of 200m head at Zatory PS	New Valves
	Zatory - Khaldyeh line	Good Condition	New Valves
	Branch lines from wells to transmission mains	Replacement recommended	
West Transmission System	Line from Tabaqat Fahel to Wadi Arab PS0	Excellent Condition	Maintenance
	Line from Wadi Arab PS0 to PS1	Excellent Condition	Maintenance
	Line from Wadi Arab PS1 to Zubdat reservoir	Excellent Condition	Maintenance
	Pipeline from Zubdat to Hofa	Excellent Condition	Maintenance
	Branch lines from wells to transmission mains	Replacement recommended	



Branch Lines from Wells

The branch lines connecting the wells with the main pipelines vary in size from 150mm to 400 mm. Many of these lines are old and suffering from corrosion. The majority of these lines are made from un-lined black steel pipe that is highly susceptible to corrosion and tuberculation. As a result, essentially all of the branch lines should be replaced.

A.4.2 West Transmission System

Four major pipelines have been evaluated, in addition to the branch lines that connect wells to the transmission system. Tabaqat Fahel pipeline carries flow by gravity from the collection tank for the well field northward in the Jordan Valley to the Wadi Al Arab PS0; a second pipeline connects PS0 to the Wadi Al Arab water treatment plant and Wadi Al Arab PS1; a third pipeline connects PS1 through PS2 and PS3 to the Zubdat reservoir in Irbid; and a fourth pipeline connects Zubdat reservoir to Hofa reservoir. The evaluation of these pipelines is described below.

Tabaqat Fahel – Wadi Al Arab PS0 Pipeline

This 19km pipeline carries flow by gravity, through a 600mm diameter ductile-iron pipe, with push-on joints, of pressure class k9, cement-lined internally and bitumen-coated externally. Currently, the pipeline carries an average flow of 650-680 m³/h, much less than its capacity of 1250 m³/h. The pipeline is new, installed in 1997, and is in excellent condition. The air valves and washout valves are in good condition, and only need periodic preventive maintenance. The washout valves should be operated periodically to flush any accumulation of sediment in the low-lying portions of the pipeline.

Wadi Al Arab PS0 – Wadi Al Arab PS1 Pipeline

This 7.8km pipeline is a 600 mm diameter steel pipe with welded joints, class X42, cement-lined internally and wrapped externally with polythene sheeting. The pipeline was constructed in 1997, and transmits an average flow of 740-770 m³/h, which is considerably less than the pump-station capacity of 1250 m³/h.

The pipeline is in excellent condition. The air valves and washout valves are in good condition, and only need periodic preventive maintenance. The washout valves should be operated periodically to flush any accumulation of sediment from the pipeline.

Wadi Al Arab PS1 - Zubdat Reservoir Pipeline

This 24 km pipeline is an 800mm diameter ductile-iron pipe with push-on joints, pressure class k9, cement-lined internally and bitumen-coated externally. It was constructed in 1983, and currently transmits about 2200m³/h.

The pipeline is in good condition. The air valves and washout valves are in good condition, and only need periodic preventive maintenance. The washout valves should be operated periodically to flush any accumulation of sediment from the pipeline.

Zubdat Reservoir – Hofa Pipeline

This 6km pipeline is a 600mm diameter ductile-iron pipe with push-on joints, pressure class k9, cement-lined internally and bitumen-coated externally. It was constructed in 1997. The pipeline is new and in excellent condition. The air valves and washout valves are in good

condition, and only need periodic preventive maintenance. The washout valves should be operated periodically to flush any accumulation of sediment from the pipeline.

Branch Lines from Wells

As in the east transmission system, most of the branch lines connecting the wells with the main pipelines vary in size from 150mm to 400 mm. Many of these lines are old and suffering from corrosion. The majority of these lines are made from un-lined black steel pipe that is highly susceptible to corrosion and tuberculation. As a result, essentially all of these branch lines should be replaced.

An exception is the condition of the branch lines for the Wadi Al Arab wells, which are made of ductile iron, cement-lined and externally coated. These lines are in much better condition, and do not need replacement.